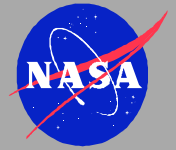


Mobile Agents Integrate Astronauts, Rover, & Mission Support in Desert-RATS Mission Simulation



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Ames Research Center

Maarten Sierhuis (co-PI)

John Dowding (Language)

Dan Berrios (Database)

Mike Scott (Agents)

Ron van Hoof (Habcom)

Johnson Space Center

Frank Delgado (SCOUT)

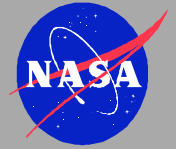
Susan Torney (ExPOC)

Joe Kosmo (Suits)

*In collaboration with many others from JSC, KSC,
GRC, and Hamilton Sundstrand...*



About Desert-RATS



- NASA-led research “working group”
- Eight annual field trip; Apollo training legacy
- Four NASA centers and external partners (USGS, industry, academia)
- Preparing for human-robotic exploration
- Integrates projects into coordinated field test
- Goal: Develop EVA operational concepts in analog setting through hands-on experience.

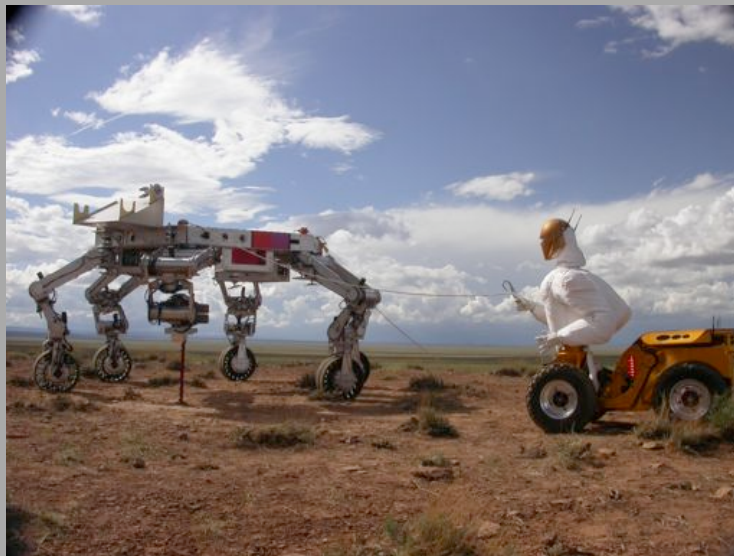
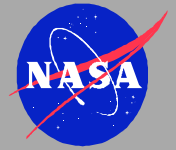


Field Layout





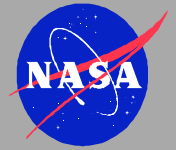
Robonaut & Athlete





Mobile Agents @ D-RATS06

Objectives

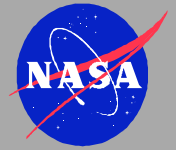


Test subjects conducting simulated extravehicular activity (EVA) while wearing pressurized space suits and using a prototype rover vehicle

- Demonstrate first end-to-end systems integration between mission support and people & robotic systems at a remote site
- Show generality of agent-based systems integration
 - Autonomous drives of SCOUT
 - Control of multiple cameras
 - Programmed control of the Planetary Exploration Geophone System (PEGS) hardware
 - Remote access to telemetry & voice commanding
 - Heads-up display



System Configuration



Suit & CAI Pack



ExPOC@ JSC



SCOUT & PEGS

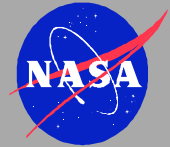


HabCom @ Meteor Crater

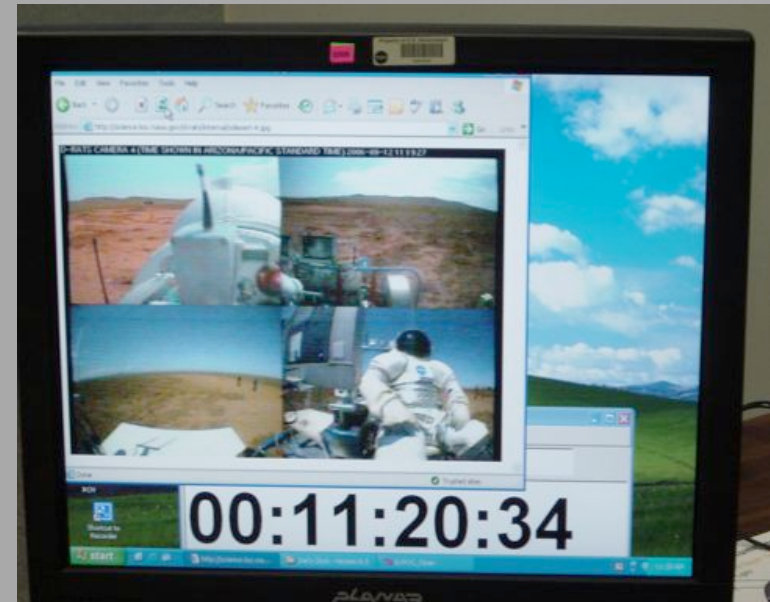




ExPOC Activities

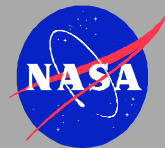


- Commanded SCOUT to execute an autonomous plan, e.g., move & take pictures.
- Interacted with crew and Habcom via voice mail.
- Observed status of EVA on aerial photographs showing movements of Scout & crew and photographs, samples, and voice notes.
- Received alerts and emails with links to database created by Mobile Agents



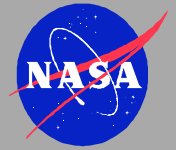


Video





Example Scout Protocol



EV1 is off vehicle, which is nearby:

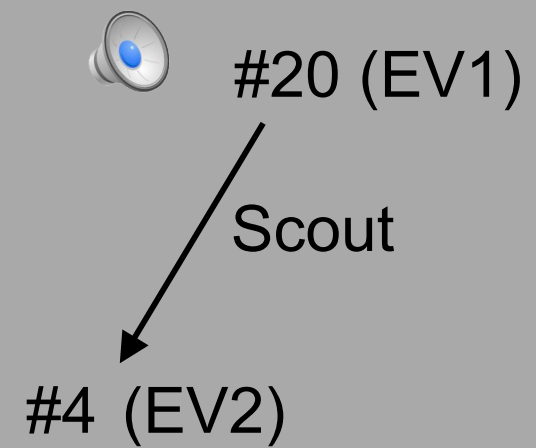
- **Create waypoint 20**
- **Where am I?** (“Waypoint 20”)
- **Where is EV2?** (“Waypoint 4”)
- **Scout, move to Waypoint 4**
(Autonomous, no riders)

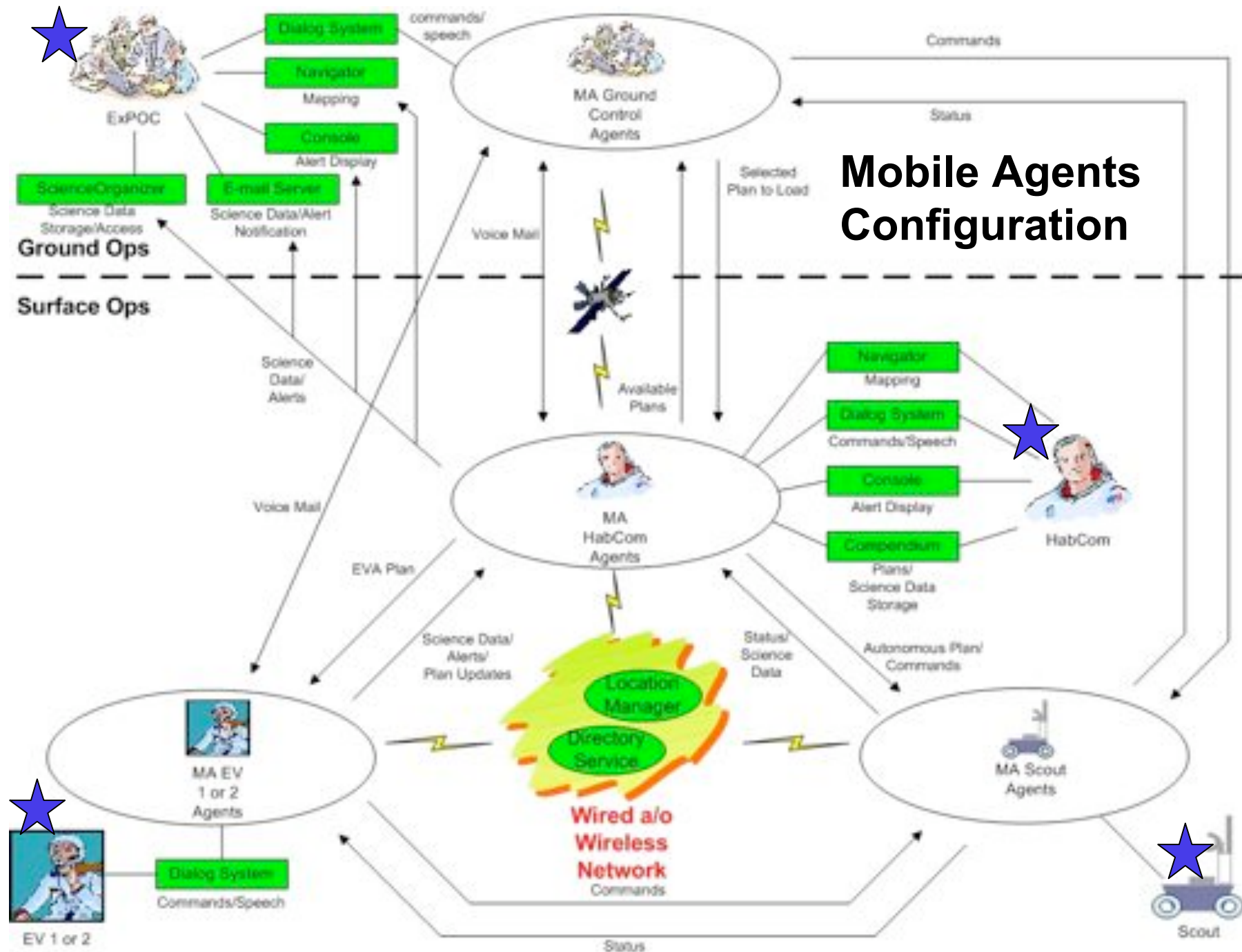
EV1 works in area of Waypoint 20.

EV2 gets onboard Scout when it arrives.

- **Scout drive to Waypoint 20**
(Autonomous drive back to EV1)

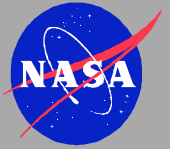
On arrival, EV1 joins EV2 onboard Scout.







D-RATS06 Voice Commands



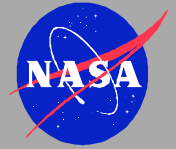
- **Interaction**

- Hello | Acknowledge
- {INCREASE | DECREASE} volume
- Repeat that
- Please stop talking
- Go to sleep
- Wake up



- **Heads-Up Display**

- {DISPLAY | SHOW | HIDE | CLOSE}
 {POWERPOINT | DOCUMENT | JPEG} <#>
- Page {UP | DOWN}
- Zoom {IN | OUT}
- Pan {LEFT | RIGHT | UP | DOWN}



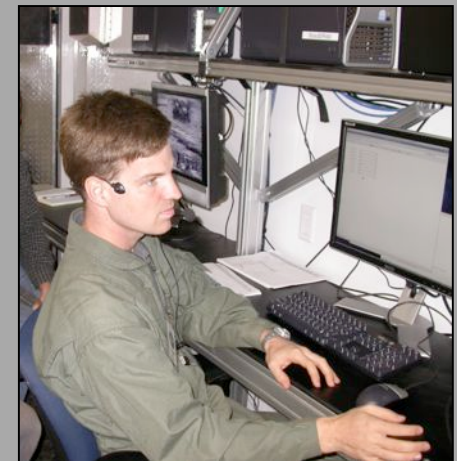
Location & Activity Voice Commands

- Location

- Where am I?
- Where is {EV1 | EV2 | SCOUT | WAYPOINT # | WORKSITE #} {relative to {<LOCATION>}}
- {CALL THIS LOCATION | CREATE} {WAYPOINT # | WORKSITE #}

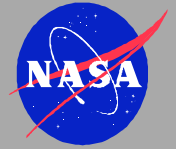
- Activities

- What is {my | EV1 | EV2's} {CURRENT | NEXT} activity?
- {WHAT | WHERE} is my next activity?
- Start {MY} {FIRST | NEXT} activity.
- How much time is left?
- What time is it?
- Extend duration by # minutes.
- Change duration to # minutes.





Scout Voice Commands

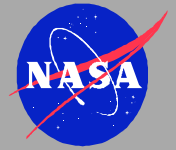



- Scout halt.
- Scout take a picture of <PLACE> = {EV1 | EV2 | ME | WAYPOINT # | WORKSITE #}
- Scout take a panorama.
- Scout plan a path to <PLACE>
- Scout {DRIVE | MOVE} to <PLACE>
- Scout {PREPARE TO | ON MY ORDER} follow {EV1 | EV2 | ME}
- Scout follow {EV1 | EV2 | ME}
- Scout {WATCH | STOP WATCHING} <PLACE>
- Scout who are you watching?
- Scout, execute the plan





Science Voice Commands

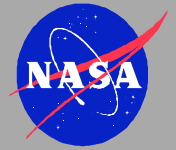





- Record a voice note.
- Continue {LAST} voice note.
- Send {LAST} voice note {# } to {EV1 | EV2 | HABCOM | EXPOC} 
- {RECORD | TAKE} a voice {NOTE | MAIL} for <AGENT>
- List voice notes.
- Create a sample bag.
- List sample bags.



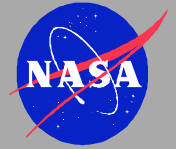


Speech Recognition Research



- Goal: Replicate MDRS voice commanding quality in actual space suits
- Audio noise is the limiting factor
- Desert Rats '05
 - 13% Word Error; False Accept and False Recognize rates over 20%
 - Unacceptable for practical use
- Desert Rats '06
 - Significantly improved audio
 - Best results with “snoopy cap”
 - Mark III – array mic 
 - Mark III - snoopy cap 
 - I-Suit 



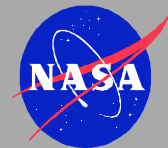


Some Lessons Learned

- **Voice commands:** Wording, Confirmation, Contextual interpretation (e.g., “yeah”)
- **Parallel work:** Multiple voice channels &/or mute; Don't interrupt human conversations
- **Protocols:** Should “start my next activity” cause Scout to drive?
- **Training:** Focus on recurrent sequences
- **Information Display**
 - Represent more on dynamic map
 - Diagram communication history (for ExPOC)
 - State of activity plan

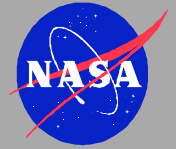


D-RATS06 Visitor Day

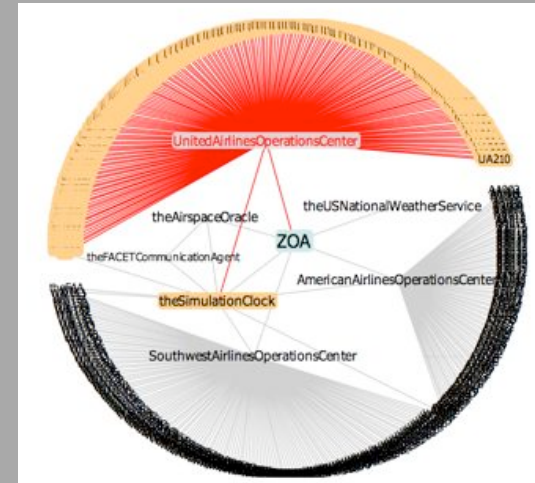




Other Brahms/MA Projects



Power Agents at MDRS



ATC-Airline Decision Making



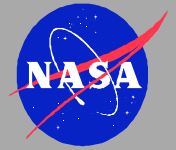
POGO: Metabolic Rate Advisor



OCAMS: ISS File Management



For more information...



- **D-RATS:**
<http://science.ksc.nasa.gov/d-rats/>
- **Brahms/Mobile Agents:**
www.agentisolutions.com
- **Publications:**
<http://bill.clancey.name>



Joe Kosmo wearing CAIPack assisting Keith Splawn of ILC-Dover in pressurized I-Suit



Desert-RATS 2006 Team